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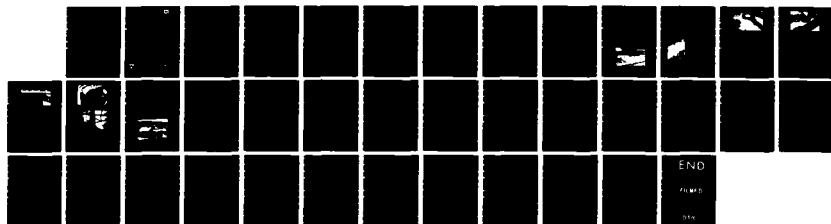
SURVEY OF ICE PROBLEM AREAS IN NAVIGABLE WATERWAYS(U)  
COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH  
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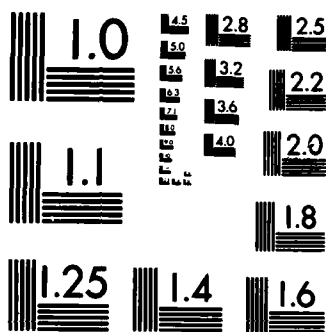
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# Special Report 85-2

April 1985



**US Army Corps  
of Engineers**

Cold Regions Research &  
Engineering Laboratory

## *Survey of ice problem areas in navigable waterways*

Jon Zufelt and Darryl Calkins

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## SURVEY OF ICE PROBLEM AREAS IN NAVIGABLE WATERWAYS

Jon Zufelt and Darryl Calkins

### INTRODUCTION

#### Purpose

This report describes a survey undertaken by the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) to identify ice problems encountered on some of the major navigable U.S. rivers. The hydraulic flow conditions of a river, coupled with the effects of an ice cover, can cause problems that may greatly impede winter navigation. Through the survey, we wanted to identify specific problem areas, such as lock approaches, spillway gates, and main river channel areas, where ice (whether moving or stationary, solid or jammed) causes more than routine difficulty. Just as important as identifying the ice problems encountered are the methods of dealing with them. We sought information on necessary changes in operational procedures at lock and dam projects due to ice. We also hoped to learn of any structural modifications made to existing equipment, or designed into new structures, with ice control as a primary or secondary design feature. Documentation of the ice problems, operational changes, and the performance of structures and modifications is extremely important, and we requested copies of reports or memoranda addressing these aspects.

This survey effort was undertaken to provide background and to assist in planning the execution of the River Ice Management (RIM) Program. The purpose of the RIM program is to develop structural and operational solutions to ice problems on our nation's navigable inland waterways. The RIM program is being carried out by CRREL through its Ice Engineering Research Branch. The program is being monitored by the Office of the Chief of Engineers, in Washington, D.C., and an advisory group of six representatives from various Corps Divisions and Districts comprises a Field Review Group. The Field Review Group acts as an advisory body and as a liaison between the personnel at CRREL and the Divisions and Districts involved.

### River selection

Although the River Ice Management Program will benefit all navigable rivers that experience ice problems, work under the program is primarily on the Ohio River, the Illinois Waterway, and the ice-prone portions of the Mississippi River that are navigated year-round. Our survey was aimed at these rivers as well as the navigable sections of the Allegheny, Monongahela, Kanawha, Kaskaskia, and Missouri Rivers, and the portion of the Mississippi River that is closed in winter.

The results of the survey are being used by many elements of the RIM program, not only for identifying areas where ice problems exist, but also to learn what is currently being done to alleviate these problems. Information from the survey will guide many studies during the life of the RIM program and, through this report, will be available to all interested parties.

### METHOD

#### Questionnaire development

At least 3 of the 13 work units involved in the River Ice Management Program require information on ice problems for guidance in their study-plan formulation, as well as for determining what problems actually exist. Information desired includes problem location, problem description, whether there are hydraulic structures involved, operational and/or structural modifications implemented, problem severity, and point of contact for further discussion of the ice problem.

Rather than sending out an unstructured request for information, it was decided that a questionnaire format might offer guidance and provide some uniformity to the information received. The questionnaire was developed according to the above information requirements. A sample survey questionnaire is presented in Appendix A. Problem location was denoted by river name and river mile, as well as by any named hydraulic structure, such as a lock and dam facility. The problem area was categorized according to bends, islands, spillway gates, and lock gates and approaches. Problems not fitting one of these areas could be designated as "other." Ample space was provided for a thorough description of the ice problem encountered. Any known documentation of the problem could be referenced, and copies of reports or memoranda were requested. Information concerning attempts to alleviate the ice problem was requested and whether these were operational or structural modifications.

Again documentation was requested. The recipients were asked to rank the severity of the ice problem as it compares to other ice problems in their jurisdiction. Finally, the questionnaire asked for information concerning any structures that were specifically designed, modified, or retrofitted to alleviate the ice problem. Location of the structure and a point of contact for further discussion on this structure were also requested. Although the survey questionnaire was structured, it was hoped that the recipients would feel free to add any information they deemed useful.

#### Selection of recipients

It was believed that the members of the Field Review Group would have a better idea of where current ice problems existed, and also would know whom to contact in regard to the information desired within their respective Division or District. Therefore, survey questionnaires were delivered to the Field Review Group members with the request that they direct them to the appropriate personnel in the Operations and Hydraulic Design units within their jurisdiction. General requests for ice problem information (rather than the questionnaire forms), along with a description of the RIM program, were sent to the Omaha and Kansas City Districts concerning the Missouri River in the Missouri River Division, since these areas are not represented in the membership of the Field Review Group.

#### RESULTS

The response was excellent, with information being received on ice problems occurring on the Allegheny, Monongahela, Ohio, Kanawha, Mississippi, Kaskaskia, and Missouri Rivers and the Illinois Waterway. In general, the questionnaires were completed by lock and dam personnel with additional reports from operations personnel in the headquarters offices of the various Divisions and Districts involved. A list of the respondents is presented in Appendix B. A response was received from nearly every lock and dam on the above rivers that generally included information concerning the reaches between lock and dam facilities in addition to data on the navigation structures themselves. Problem locations and descriptions were detailed with many respondents including maps, sketches, or photos in addition to the completed questionnaires. Although many reports and memoranda were referenced, few copies were received. Operational or structural changes as a result of the ice problems, and the effectiveness of these changes, were mentioned in many

cases. Nearly all of the questionnaire responses gave names of personnel (usually lockmasters) who would be helpful in further discussion of the ice problems.

The questionnaire responses were evaluated and the ice problems categorized. Ten ice problem categories were found to occur at lock and dam facilities, while three additional categories were incident to locations other than lock and dam facilities. Descriptions of each category of ice problem follow. Each description includes cited methods, operational and/or structural, undertaken to alleviate the problem.

#### Ice in upper lock approach

Broken ice carried downstream by the river current or wind often accumulates in the upper lock approach, causing delays (Fig. 1). Separate ice lockages often must precede the locking of downbound tows, and flushing ice during these ice lockages is difficult. Occasionally a tow must back out of the lock after entry, because the ice doesn't compact in the chamber as much as expected, preventing the tow from fully entering the lock chamber and thus causing further delays. Upbound tows may have to limit their size to be assured of enough power to push through the accumulations of ice. During periods of low traffic, these accumulations sometimes freeze in place, causing further delays and difficulty in operating the upper gates. Air bubbler curtains have been used at some installations to deflect ice from the lock ap-

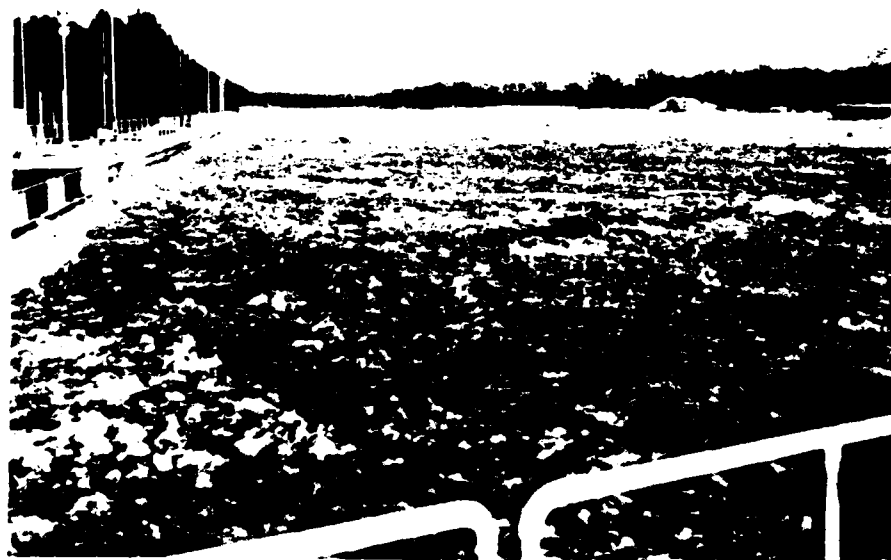


Figure 1. Ice in upper lock approach.

proach. Towboats sometimes align their barges to act as a deflector wall while awaiting downbound lockage. Some locks are equipped with emergency bulkheads that are placed in the small lock chamber to act as spillways, flushing ice from the upper approach. One respondent cited that with greater towboat approach velocities, the ice is pushed to the sides of the incoming barges, rather than being directed forward into the lock chamber.

#### Lock miter gates - fragmented ice floes

Ice accumulations in the upper lock approach cause pieces of ice to accumulate or become wedged between the miter gates and the wall recesses (Fig. 2). The gates must be fanned or the ice pieces prodded with pike poles to fully open the upper gates. Ice pushed into the lock chamber ahead of downbound tows causes the same difficulties in fully opening the lower gates. Air bubblers are used in most gate recesses, but are often inadequate to clear out sufficient amounts of ice. Additional effort is usually required in the form of gate fanning, pike poles, compressed air lances, or steam application.



Figure 2. Lock miter gate showing ice pieces jammed in gate recess.

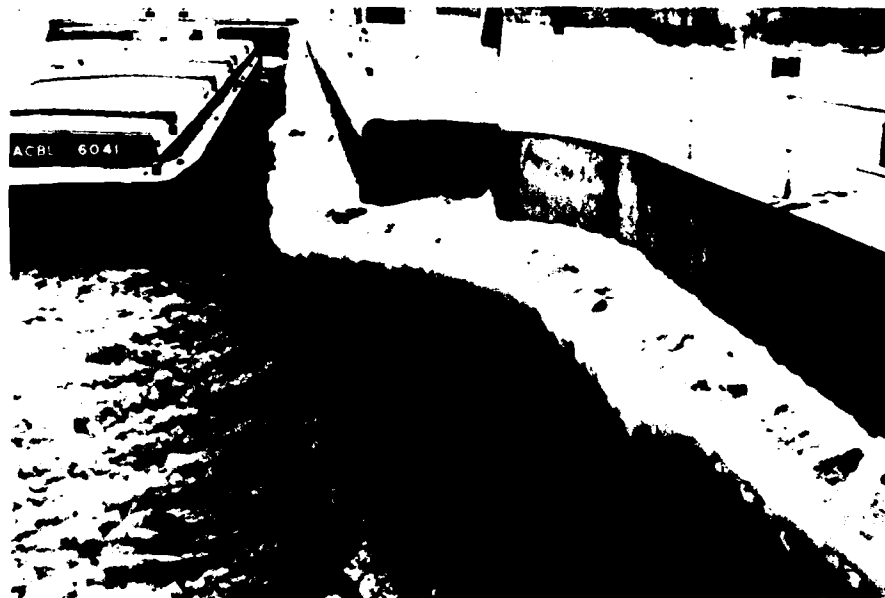


Figure 3. Ice buildup on lock walls and miter gate recesses.

#### Ice buildup on lock walls and miter gates - glazing

During extremely cold weather, and with fluctuating water levels in lock chambers, ice will build up on the lock walls and miter gates, forming a collar (Fig. 3). This collar is thickest at the upper pool level. Sufficient buildup can occur on the walls to restrict the gates from being fully opened, thus limiting the width of tows and presenting the potential for gate damage. Even where the buildup is minimized or controlled in the gate recesses, ice on the chamber walls can be thick enough to restrict tow widths. The most common methods for removing ice buildups on lock walls and miter gates are chipping and steaming. Less labor-intensive means include electric heaters on gates and wall recesses and the application of copolymer ice coatings. Ice coatings are reported to work well on lock walls but have had limited success when applied to the miter gates.

#### Floating mooring bitts

Ice pieces may jam between the floating mooring bitts and the lock wall, rendering the bitts inoperative. Ice layers may build up on the wheels or track of a bitt (Fig. 4), causing it to freeze in place and/or jump upward unexpectedly from a submerged position. Usually, bitts are tied off at the top of the lock wall and remain unavailable for winter use. Oil-fired hot water heaters have been used to keep floating mooring bitts free of ice accumulations. One facility has achieved good results from applying copolymer ice coating to the tracks and wheels of their bitts.



Figure 4. Floating mooring bitts jammed by ice accumulations.

#### Vertical checkpins

The vertical checkpins in the lock walls may build up layers of ice due to fluctuating water levels. This causes difficulties in locking through when check lines slip and jump off the pins. Oil-fired hot water heaters and chipping are cited methods of removing this ice.

#### Ice in lower lock approach

Ice may accumulate downstream of a lock due to upstream wind, an island, bend, or other constriction. Ice coming through the lock or over the spillway adds to this accumulation. The continual buildup of ice may block the entrance to the lock for upbound tows.

#### Dam spillway gates

Broken ice carried downstream usually accumulates at the navigation dam (Fig. 5). During periods of low flow, normal gate openings are small and will not pass this ice. Low tailwater presents a problem of excessive scour if gates are raised high enough to pass the ice. In colder weather these accumulations will freeze in place, making it necessary to break up the ice in order to start it or keep it moving. Towboats provide assistance to the lock and dam facilities in this respect. Some lock and dam facilities have been equipped with submergible tainter gates, specifically designed for passing ice and drift. At a few installations, the gates are rarely used in the sub-



Figure 5. Ice buildup behind dam spillway gates.

merged settings due to excessive vibrations, which could cause damage to the gate and supporting structure of the dam. Some of these submergible gates have been retrofitted to prevent them from being used in the submerged position. Other lock and dam facilities report no problems with operating their gates in the submerged position. Three installations on the Monongahela River are equipped with split-leaf tainter (movable crest) gates designed for passing ice and debris. The gates are reported to work well, but during periods of low flow, towboat assistance is required to break up the ice behind the dam and start it moving. One facility reported that an emergency bulkhead placed over a roller gate bay passes ice well. Another lockmaster rotates the openings of the dam gates to keep the ice moving.

#### Spray icing of spillway gates

Spray from the operation of spillway gates can cause ice to form on the pier walls or under the arms of tainter gates (Fig. 6). This may cause jamming or prevent closing the gates fully. In some cases, the weight of ice formed on the gate structure is so great that the operating machinery cannot raise the gate. Electric heaters have been employed on the back sides of tainter gates to prevent this ice from forming. Methods of de-icing include chipping, steaming, and smudge buckets.



Figure 6. Ice buildup on trunion arms of tainter gate due to spray from gate operation.

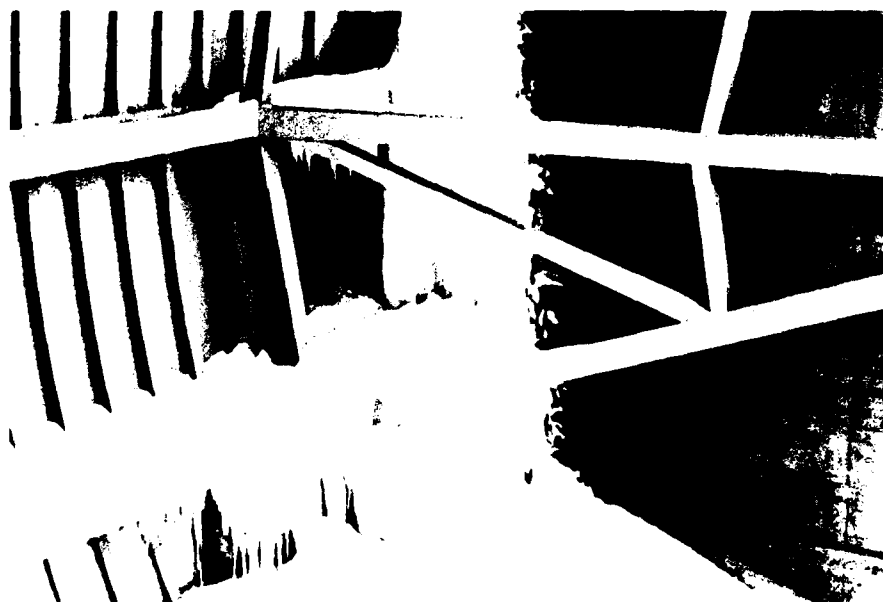


Figure 7. Ice formation due to leakage of tainter gate side seals.

#### Tainter gate seals

The side and bottom seals of tainter spillway gates may leak, causing spray. This spray results in ice buildup on the pier walls or the gates themselves, causing operational difficulty (Fig. 7). Seal heaters are commonly used to combat this problem. It is possible for this ice buildup to

bridge across from the pier to the gate, rendering the gate seal heaters ineffective and the gate inoperative. In these cases the ice is chipped or steamed off to regain operation of the gate. During severe cold, the gates must be moved frequently or they will freeze in place.

#### Ice formation on turbine intakes

Broken ice and/or frazil ice can accumulate on the trash racks of a hydropower plant, causing a reduction in flow. This results in loss of power production and shutdown if flows are substantially blocked. Compressed air is used to remove ice from intake screens.

#### Severe ice accumulations and jams

The channels around islands, bends, and other constrictions tend to accumulate thick deposits of ice (Fig. 8). During significant ice periods these accumulations may form jams, which can cause scouring and eroding of bed and banks. Navigation can be interrupted or delayed and structural damage is possible, especially during breakup of the jam. Minor jams may raise the water level upstream, while major jams can cause severe flooding. Tows must limit their size in some problem areas.



Figure 8. Section of Ohio River showing severe accumulation of ice in navigation channel.

### Tributary breakup ice

Tributary ice may break up and run before, during, or after the ice run in the main river. This breakup can result in ice jams, blockages of the main navigation channel, and ice in the upper and lower approaches. Depending on the size of the tributary and the speed of breakup, structural damage is possible.

### Docks and fleeting areas

Ice accumulates on the upstream side of docks and moored vessels. In heavy ice runs this accumulation may be enough to break moored vessels loose or to cause structural damage to the docks and mooring areas. Ice accumulations may also deny access to docks and fleeting areas. The Huntington District has installed ice piers (rock-filled, sheet pile cells) in several locations to deflect ice and provide a safe harbor for moored vessels.

### Tables

Tables 1 through 12 list the problem sites according to problem type. Tables 13 through 18 list the sites and their problems by river basin. Within each listing by river, the sites are listed in downstream order. Table 19 lists the methods used to reduce the impact of ice problems.

Table 1. Facilities experiencing ice in the upper lock approach.

<u>Lock and Dam</u>	<u>River</u>	<u>River Mile</u>
Lock No. 9	Allegheny	62.2
Lock No. 8	"	52.6
Lock No. 7	"	45.7
Lock No. 6	"	36.3
Lock No. 5	"	30.4
Lock No. 4	"	24.2
Lock No. 3	"	14.5
Lock No. 2	"	6.7
Opekiska	Monongahela	115.4
Hildebrand	"	108
Morgantown	"	102
Lock No. 8	"	90.8
Lock No. 7	"	85
Maxwell	"	61.2
Lock No. 4	"	41.5
Lock No. 3	"	23.8
Lock No. 2	"	11.2
Emsworth	Ohio	6
Dashields	"	13.3
Montgomery	"	31.7
New Cumberland	"	54.4
Pike Island	"	84.2

Table 1 (cont'd). Facilities experiencing ice in the upper lock approach.

Hannibal	Ohio	126.4
Willow Island		162
Belleville	"	204
Racine	"	238
Gallipolis	"	279
Greenup	"	341
Meldahl	"	436
Markland	"	531.5
McAlpine	"	606.8
Cannelton	"	720.7
Newburgh	"	776.1
Uniontown	"	846.0
Smithland	"	918.5
Lock 52	"	938.9
Lock 53	"	962.6
London	Kanawha	83
Marmet	"	68
Winfield	"	31
O'Brien	Illinois	326
Dresden Island	"	271.5
Marseilles	"	244.6
Starved Rock	"	231
Peoria	"	158
LaGrange	"	80.2
Upper St. Anthony Falls	Mississippi	854
Lower St. Anthony Falls	"	854
L/D 1	"	848
L/D 2	"	815
L/D 3	"	797
L/D 4	"	753
L/D 5	"	738
L/D 5A	"	729
L/D 6	"	714
L/D 7	"	703
L/D 8	"	679
L/D 9	"	648
L/D 10	"	615
L/D 11	"	583
L/D 12	"	556.7
L/D 14	"	493
L/D 15	"	482.9
L/D 16	"	457.2
L/D 17	"	437
L/D 18	"	410.5
L/D 19	"	364.2
L/D 20	"	353.2
L/D 21	"	325
L/D 22	"	301.1
L/D 24	"	273.4
L/D 25	"	241.4
L/D 26	"	202.9
L/D 27	"	185.1
Kaskaskia	Kaskaskia	0.8

Table 2. Facilities experiencing problems with lock miter gates -  
fragmented ice floes.

<u>Lock and Dam</u>	<u>River</u>	<u>River Mile</u>
Lock No. 9	Allegheny	62.2
Lock No. 8	"	52.6
Lock No. 7	"	45.7
Lock No. 6	"	36.3
Lock No. 5	"	30.4
Lock No. 4	"	24.2
Lock No. 3	"	14.5
Lock No. 2	"	6.7
Opekiska	Monongahela	115.4
Hildebrand	"	108
Morgantown	"	102
Lock No. 8	"	90.8
Lock No. 7	"	85
Maxwell	"	61.2
Lock No. 4	"	41.5
Lock No. 3	"	23.8
Lock No. 2	"	11.2
Emsworth	Ohio	6
Dashields	"	13.3
Montgomery	"	31.7
New Cumberland	"	54.4
Pike Island	"	84.2
Hannibal	"	126.4
Willow Island	"	162
Belleville	"	204
Racine	"	238
Gallipolis	"	279
Greenup	"	341
Meldahl	"	436
Markland	"	531.5
McAlpine	"	606.8
Cannelton	"	720.7
Newburgh	"	776.1
Uniontown	"	846.0
Smithland	"	918.5
Lock 52	"	938.9
Lock 53	"	962.6
London	Kanawha	83
Marmet	"	68
Winfield	"	31
O'Brien	Illinois	326
Dresden Island	"	271.5
Marseilles	"	244.6
Starved Rock	"	231
Peoria	"	158
LaGrange	"	80.2

Table 2 (cont'd). Facilities experiencing problems with lock  
meter gates - fragmented ice floes.

Upper St. Anthony Falls	Mississippi	854
Lower St. Anthony Falls	"	854
L/D 1	"	848
L/D 2	"	815
L/D 3	"	797
L/D 4	"	753
L/D 5	"	738
L/D 5A	"	729
L/D 6	"	714
L/D 7	"	703
L/D 8	"	679
L/D 9	"	648
L/D 10	"	615
L/D 11	"	583
L/D 12	"	556.7
L/D 14	"	493
L/D 15	"	482.9
L/D 16	"	457.2
L/D 17	"	437
L/D 18	"	410.5
L/D 19	"	364.2
L/D 20	"	353.2
L/D 21	"	325
L/D 22	"	301.1
L/D 24	"	273.4
L/D 25	"	241.4
L/D 26	"	202.9
L/D 27	"	185.1
Kaskaskia	Kaskaskia	0.8

Table 3. Facilities experiencing ice buildup on lock walls and  
miter gates - glazing.

<u>Lock and Dam</u>	<u>River</u>	<u>River Mile</u>
Lock No. 5	Allegheny	30.4
Lock No. 4	"	24.2
Lock No. 8	Monongahela	90.8
Lock No. 7	"	85
Lock No. 4	"	41.5
O'Brien	Illinois	326
Marseilles	"	244.6
Starved Rock	"	231
Peoria	"	158
Upper St. Anthony Falls	Mississippi	854
Lower St. Anthony Falls	"	854
L/D 1	"	848
L/D 2	"	815
L/D 3	"	797
L/D 4	"	753

Table 3 (cont'd). Facilities experiencing ice buildup on lock walls and miter gates - glazing.

L/D 5	"	738
L/D 5A	"	729
L/D 6	"	714
L/D 7	"	703
L/D 8	"	679
L/D 9	"	648
L/D 10	"	615
L/D 11	"	583
L/D 12	"	556.7
L/D 14	"	493
L/D 15	"	482.9
L/D 16	"	457.2
L/D 17	"	437
L/D 18	"	410.5
L/D 19	"	364.2
L/D 20	"	353.2
L/D 21	"	325
L/D 22	"	301.1
L/D 24	"	273.4
L/D 25	"	241.4
L/D 26	"	202.9
L/D 27	"	185.1
Kaskaskia	Kaskaskia	0.8

Table 4. Facilities experiencing floating mooring-bitt problems.

<u>Lock and Dam</u>	<u>River</u>	<u>River Mile</u>
New Cumberland	Ohio	54.4
Willow Island	"	162
Belleveille	"	204
Racine	"	238
Gallipolis	"	279
Greenup	"	341
Meldahl	"	436
London	Kanawha	83
Marmet	"	68
Winfield	"	31

Table 5. Facilities experiencing vertical checkpin problems.

<u>Lock and Dam</u>	<u>River</u>	<u>River Mile</u>
Opekiska	Monongahela	115.4
Hildebrand	"	108
Morgantown	"	102
Lock No. 8	"	90.8
Lock No. 7	"	85
Maxwell	"	61.2
Lock No. 4	"	41.5
Lock No. 3	"	23.8
Lock No. 2	"	11.2
Gallipolis	Ohio	279

Table 6. Facilities experiencing ice in the lower lock approach.

<u>Lock and Dam</u>	<u>River</u>	<u>River Mile</u>
Lock No. 9	Allegheny	62.2
Lock No. 8	"	52.6
Lock No. 5	"	30.4
Lock No. 4	"	24.2
Lock No. 2	"	6.7
Maxwell	Monongahela	61.2

Table 7. Facilities experiencing difficulty passing ice over dam spillway gates.

<u>Lock and Dam</u>	<u>River</u>	<u>River Mile</u>
Opekiska	Monongahela	115.4
Hildebrand	"	108
Morgantown	"	102
Lock No. 8	"	90.8
Lock No. 7	"	85
Maxwell	"	61.2
Lock No. 4	"	41.5
Lock No. 3	"	23.8
Lock No. 2	"	11.2
Emsworth	Ohio	6
Dashields	"	13.3
Montgomery	"	31.7
New Cumberland	"	54.4
Pike Island	"	84.2
Hannibal	"	126.4
Willow Island	"	162
Belleville	"	204
Racine	"	238
Gallipolis	"	279
Greenup	"	341

Table 7 (cont'd).

Meldahl	"	436
Markland	"	531.5
McAlpine	"	606.8
Cannelton	"	720.7
Newburgh	"	776.1
Uniontown	"	846.0
Smithland	"	918.5
Lock 52	"	938.9
Lock 53	"	962.6
London	Kanawha	83
Marmet	"	68
Winfield	"	31
O'Brien	Illinois	326
Dresden Island	"	271.5
Marseilles	"	244.6
Starved Rock	"	231
Peoria	"	158
LaGrange	"	80.2
Coon Rapids	Mississippi	870
Upper St. Anthony Falls	"	854
Lower St. Anthony Falls	"	854
L/D 1	"	848
L/D 2	"	815
L/D 3	"	797
L/D 4	"	753
L/D 5	"	738
L/D 5A	"	729
L/D 6	"	714
L/D 7	"	703
L/D 8	"	679
L/D 9	"	648
L/D 10	"	615
L/D 11	"	583
L/D 12	"	556.7
L/D 14	"	493
L/D 15	"	482.9
L/D 16	"	457.2
L/D 17	"	437
L/D 18	"	410.5
L/D 19	"	364.2
L/D 20	"	353.2
L/D 21	"	325
L/D 22	"	301.1
L/D 24	"	273.4
L/D 25	"	241.4
L/D 26	"	202.9
L/D 27	"	185.1
Kaskaskia	Kaskaskia	0.8

Table 8. Facilities experiencing spray icing of spillway gates.

<u>Lock and Dam</u>	<u>River</u>	<u>River Mile</u>
Lock No. 8	Monongahela	90.8
Willow Island	Ohio	162
Belleville	"	204
Racine	"	238
Greenup	"	341
Meldahl	"	436
Marseilles	Illinois	244.6
Starved Rock	"	231
Coon Rapids	Mississippi	870
Upper St. Anthony Falls	"	854
Lower St. Anthony Falls	"	854
L/D 1	"	848
L/D 2	"	815
L/D 3	"	797
L/D 4	"	753
L/D 5	"	738
L/D 5A	"	729
L/D 6	"	714
L/D 7	"	703
L/D 8	"	679
L/D 9	"	648
L/D 10	"	615
L/D 24	"	273.4
L/D 25	"	241.4
L/D 26	"	202.9

Table 9. Facilities experiencing leakage at tainter gate seals.

<u>Lock and Dam</u>	<u>River</u>	<u>River Mile</u>
Morgantown	Monongahela	102
Hannibal	Ohio	126.4
Dresden Island	Illinois	271.5
L/D 18	Mississippi	410.5
L/D 21	"	325

Table 10. Facilities experiencing ice buildup and formation on turbine intakes.

<u>Lock and Dam</u>	<u>River</u>	<u>River Mile</u>
Dashields	Ohio	13.3

Table 11. Locations of severe ice accumulations or jams.

<u>Location</u>	<u>River</u>	<u>Mile or Reach</u>
Pend	Allegheny	23.7
Bend	"	16.5
14 Mile Island	"	15
Hatfield Power-Cumberland Mine	Monongahela	78.5-65.8
Millsboro Bend	"	65-65.8
Redstone Light	"	54.8-55.5
Cresent Mine Light	"	53-54
California Bend	"	52-53
Greenfield Bend	"	50-51
Bend	Ohio	105
Bend	"	122
Bend at Mooring Cells	"	125
St. Mary's Bend	"	154.5-156
Hocking River Bend	"	198-200
Long Bottom Bend	"	208-210
Swan Far	"	213-215
Ravenswood Bend	"	220-223
Letart Island	"	235-237.5
Scioto R. - New Boston, OH	"	352-356.5
Brush Creek Island	"	387-388
Manchester Islands	"	393.5-403.5
Cabin Creek Bend	"	401.5-403.5
Augusta KY-Meldahl Dam	"	429-436.2
Below Landing Creek	"	515
Carrsville	"	895
Entire reach	Big Sandy	0-8.0
Entire reach	Muskingum	0-5.5
Johnson Island Cut	Illinois	249-250
Marseilles Canal	"	244.5-247
Bend	"	243.7
Bend	"	242.9
Bull's Island and Bend	"	240.6-242
Mayo Island and Bend	"	237.2
Peoria Lake	"	162-182
Entire reach	"	137-138
Island	"	95
Bend	"	94.5
Bend	"	88.5
Tributary mouth	Mississippi	545-549
Bend and island	"	539-541
Reach	"	473-478
Islands and bends	"	460-470
Bend and islands	"	424-429
Bend	"	420
Bend	"	415
Island and bend	"	391-396
Entire reach	"	344-361.5
Island and bend	"	312.5-317

Table 11 (cont'd). Locations of severe ice accumulations or jams.

Chain of Rocks Canal	Mississippi	184-193
Fort Chartres Bend	"	130-131.5
Ste. Genevieve Bend	"	120-121
Bend	"	93.5-95.5
Fountain Bluff	"	82.5-83
Grand Tower Chute	"	77.5-79
Cape Rock Bend	"	54-55
Bend	"	45.5-46.5
Dike Field	"	41-43.7
Rock structure	"	38-40
Narrow reach	"	29.5-30
Bend	"	23-25
Bend	"	13-17
Bend	"	6-8
Bend	"	2-5
Rends	Des Moines	1-6
Entire reach	Rock	0-6

Table 12. Locations experiencing tributary ice accumulations.

<u>Locations</u>	<u>River</u>	<u>River Mile</u>
Lock No. 5	Allegheny	30.4
Lock No. 2	Monongahela	11.2
L/D 12	Mississippi	556.7
Tributary mouth	"	545-549
Bend and islands	"	424-429
L/D 18	"	410.5
Island and bend	"	391-396
L/D 19	"	364.2
Entire reach	"	344-361.5
L/D 20	"	343.2
L/D 27	"	185.1
Chain of Rocks Canal	"	184-193

Table 13. Allegheny River ice problems.

Location	River mile	Problem severity (high, medium or low)									
		Upper lock approach	Miter gates	Glazing	Floating mooring bitts	Vertical checkpins	Lower lock approach	Spillway gates	Spray icing	Tainter gate seals	Accumulations/jams
Lock No. 9	62.2	H	H				H				
Lock No. 8	52.6	H	H				H				
Lock No. 7	45.7	H	H								
Lock No. 6	36.3	H	H								
Lock No. 5	30.4	H	H	M			M				M
Lock No. 4	24.2	H	H	H			H				
Bend	23.7									H	
Bend	16.5									H	
14 Mile Island	15.0									H	
Lock No. 3	14.5	H	H								
Lock No. 2	6.7	H	H				H				

Table 14. Monongahela River ice problems.

Location	River mile	Problem severity (high, medium or low)									
		Upper lock approach	Miter gates	Glazing	Floating mooring bitts	Vertical checkpins	Lower lock approach	Spillway gates	Spray icing	Tainter gate seals	Accumulations/jams
Opekiska L/D	115.4	H	H			H		H			
Hildebrand L/D	108	H	H			H		H			
Morgantown L/D	102	H	H			H		H	H		
Lock No. 8	90.8	H	H	H		H		H			
Lock No. 7	85	H	H	H		H					
Hatfield Power-Gumberland Mine	78.5-81									H	
Millsboro Bend	65-65									H	
Maxwell L/D	61.2	H	H			H	H	H		H	
Redstone Light	54.8-55.5									H	
Crescent Mine Light	53-54									H	
California Bend	52-53									H	
Greenfield Bend	50-51									H	
Lock No. 4	41.5	H	H	H		H		H			
Lock No. 3	23.8	L	L			L					
Lock No. 2	11.2	H	H			H					H

Table 15. Ohio River ice problems.

Location	River mile	Problem severity (high, medium or low)									
		Upper lock approach	Miter gates	Glazing	Floating mooring bitts	Vertical checkpins	Lower lock approach	Spillway gates	Spray icing	Tainter gate seals	Accumulations/jams
Emsworth L/D	6	H	H				H				
Dashields L/D	13.3	H	H							H	
Montgomery L/D	31.7	H	H				H				
New Cumberland L/D	54.4	H	H		M		H				
Pike Island L/D	84.2	H	H				H				
Bend	105										H
Bend	122										H
Bend at Mooring Cells	125										H
Hannibal L/D	126.4	H	H						H		
St. Mary's Bend	154.5-156										M
Willow Island L/D	162	H	H		M			M			M
Hocking River Bend	198-200										M
Belleville L/D	204	H	H		M			M			M
Long Bottom Bend	208-210										M
Swan Bar	213-215										M
Ravenswood Bend	220-223										M
Letart Island	235-237.5										H
Racine L/D	238	H	H		M			M			
Gallipolis L/D	279	H	H		M	L					
Greenup L/D	341	H	H		M			M			
Scioto R.-New Boston, OH	352-356.5										M
Bush Creek Island	387-388										M
Manchester Islands	393.5-395.2										M
Cabin Creek Bend	410.5-403.5										M
Augusta, KY-Meldahl Dam	429-436.2										M
Meldahl L/D	436	H	H		M			M			
Below Landing Creek	515										H
Markland L/D	531.5	H	H				H				
McAlpine L/D	606.8	H	H				H				
Cannelton L/D	720.7	H	H				H				
Newburgh L/D	776.1	H	H				H				
Uniontown L/D	846	H	H				H				
Carrsville	895										H
Smithland L/D	918.5	H	H				H				
Lock 52	938.9	H	H				H				
Lock 53	962.6	H	H				H				

Table 16. Illinois River ice problems.

Location	River mile	Problem severity (high, medium or low)									
		Upper lock approach	Miter gates	Glazing	Floating mooring bitts	Vertical checkpins	Lower lock approach	Spillway gates	Spray icing	Tainter gate seals	Turbine intakes
O'Brien L/D	326	M	M				M				
Dresden Island L/D	271.5	H	H				H		H		
Johnson Island Cut	249-250										H
Marseilles Canal	244.5-247										M
Marseilles L/D	244.6	H	H				H				
Bend	243.7										H
Bend	242.9										M
Bull's Island and bend	240.6-242										M
Mayo Island and bend	237.2										M
Starved Rock L/D	231	H	H				H				
Peoria Lake	162-182										H
Peoria L/D	158	H	H				H				
Entire reach	127-137										M
Island	95										M
Bend	94.5										M
Bend	88.5										M
LaGrange L/D	80.2	H					H				

Table 17. Mississippi River ice problems.

Location	River mile	Problem severity (high, medium or low)									
		Upper lock approach	Miter gates	Glazing	Floating mooring bitts	Vertical checkpins	Lower lock approach	Spillway gates	Spray icing	Tainter gate seals	Turbine intakes
Coon Rapids Dam	870						M	M			
Upper St Anthony Falls L/D	854	H	H	H			H	H			
Lower St Anthony Falls L/D	854	H	H	H			H	H			
L/D 1	848	H	H	H			H	H			
L/D 2	815	H	H	H			H	H			
L/D 3	797	H	H	H			H	H			
L/D 4	753	H	H	H			H	H			
L/D 5	738	H	H	H			H	H			
L/D 5A	729	H	H	H			H	H			
L/D 6	714	H	H	H			H	H			
L/D 7	703	H	H	H			H	H			
L/D 8	679	H	H	H			H	H			
L/D 9	648	H	H	H			H	H			
L/D 10	615	H	H	H			H	H			
L/D 11	583	H	H	H			H				
L/D 12	556.7	L	L								L
Tributary mouth	545-549									L	L
Bend and island	539-541									L	L

Table 17 (cont'd). Mississippi River ice problems.

Location	River mile	Problem severity (high, medium or low)										
		Upper lock approach	Miter gates	Glazing	Floating mooring bitts	Vertical checkpins	Lower lock approach	Spillway gates	Spray icing	Tainter Gate seals	Turbine intakes	Accumulations/jams
L/D 14	493	H	H									
L/D 15	482.9	H	H									
Reach	473-478											
Islands and bends	460-470											
L/D 16	457.2	M	M				M					
L/D 17	437	M	M									
Bend and islands	424-429											
Bend	425											
Bend	420											
L/D 18	410.5	M	M	M					M			
Island and bend	391-396											
L/D 19	364.2	H	H	H			H					
Entire reach	344-361.5											
L/D 20	343.2	H	H				L					
L/D 21	325	H	H				H		H			
Island and bend	312.5-317											
L/D 22	301.1	H	H	H								
L/D 24	273.4	H	H	H			H	H				
L/D 25	241.4	H	H	H			H	H				
L/D 26	202.9	H	H	H			H	H				
Chain of Rocks Canal	184-193											
L/D 27	185.1	H	H	H								
Fort Chartres bend	130-131.5											
Ste Genevieve bend	120-121											
Bend	93.5-95.5											
Fountain Bluff	82.5-83											
Grand Tower Chute	77.5-79											
Cape Rock bend	54-55											
Bend	45.5-46.5											
Dike Field	41-43.7											
Rock structure	38-40											
Narrow reach	29.5-30											
Bend	23-25											
Bend	13-17											
Bend	6-8											
Bend	2-5											

Table 18. Other river ice problems.

Location	River mile	Problem severity (high, medium or low)										
		Upper lock approach	Miter gates	Glazing	Floating mooring bitts	Vertical checkpins	Lower lock approach	Spillway gates	Spray icing	Tainter gates	Turbine gate seals	Accumulations/jams
Kanawha River												
London L/D	83	M	M									
Marmet L/D	68	M	M									
Winfield L/D	31	M	M									
Kaskaskia River												
Kaskaskia L/D	0.8	H	H	H			H					
Big Sandy River												
Entire reach	0-8.0										H	
Muskingum River												
Entire reach	0-5.5										H	
Des Moines River												
Bends	1-6										L	
Rock River												
Entire reach	0-6										L	

Table 19. Methods of alleviating ice problems.

Problem	Cited methods
Upper lock approach	1,2,3,4,5
Miter gates	4,6,7,8,9
Glazing	10,11,12,13
Floating mooring bitts	13,14,15
Vertical checkpins	10,15
Lower lock approach	23
Spillway gates	3,16,17,18,19
Spray icing	7,10,11,20,21
Tainter gate seals	7,10,11,21
Turbine intakes	8
Accumulations/jams	12
Tributary ice accumulations	23
Docks and fleeting areas	22

## Key to cited methods:

- |  |                                     |
|--|-------------------------------------|
| 1. Ice lockages                        | 13. Copolymer ice coatings          |
| 2. Increased tow entrance speed        | 14. Remove from service             |
| 3. Emergency bulkhead used as spillway | 15. Hot water application           |
| 4. Air bubblers/curtains               | 16. Submersible tainter gates       |
| 5. Barges used as deflectors           | 17. Split-leaf tainter gates        |
| 6. Gate fanning                        | 18. Towboat assistance to break ice |
| 7. Steam application                   | 19. Rotate gate openings            |
| 8. Compressed air lances               | 20. Smudge buckets                  |
| 9. Pile poles                          | 21. Continued movement of gates     |
| 10. Chipping                           | 22. Ice piers                       |
| 11. Electric heaters                   | 23. No methods reported             |
| 12. Restrict tow width/size            |                                     |

## RIVER BASIN SUMMARIES

Major problems reported by most lock and dam facilities include ice in the upper lock approaches, fragmented ice becoming jammed in the miter gate recesses, difficulties passing ice through the dam spillway gates, and severe ice accumulations or jams at river bends, islands, and tributary confluences. The problems incident to each river basin are summarized below.

### Allegheny River

The lock and dam facilities on the Allegheny River have uncontrolled ogee spillways, and therefore problems with passing ice at the dam spillway gates were not reported. Some mention was made of problems of passing the ice over the spillway crest itself during low flow conditions. All eight locks reported ice in the upper lock approach and ice accumulating in the miter gate recesses. Locks 5 through 9 are normally closed during January and February due to an increase in ice and a decrease in traffic volume. Other problems include severe ice accumulations and jams at one island and two bends, as well as ice in the lower lock approach, blockages caused by tributary ice, and glazing of the miter gates and lock walls. The relative severity of each problem is listed on Table 13.

### Monongahela River

On the Monongahela River, lock and dam facilities experience ice in the upper lock approaches, ice accumulations in the miter gate recesses, and, at the gated dams, difficulty passing ice at the spillway. Severe ice accumulations or jams occur at six bends. Glazing of the miter gates, vertical checkpins, and floating mooring bitts was also reported. Other ice-related problems include tributary ice accumulations and ice formation due to leaks in the tainter gate seals as well as from spray from gate operation. Table 14 gives the relative severity of each type of problem experienced.

### Ohio River

Major problems on the Ohio River include ice in the upper lock approaches and miter gate recesses and restricted ice passage through the dam spillway gates. Severe ice accumulations and jams were reported for 16 locations on the river. Other problems reported were ice pieces jamming the floating mooring bitts, spray icing of the dam spillway gates, tainter gate seal leaks causing ice formation, shutdown of hydropower operations due to ice accumula-

tions at the intake, and a river-wide ice problem at docks and fleeting areas. The severities of these problems are listed in Table 15.

#### Kanawha River

The Kanawha River is controlled by three lock and dam facilities. Reported problems include ice in the upper lock approaches, ice jamming in the miter gate recesses, and problems associated with the floating mooring bitts. The problem severities are listed in Table 18.

#### Illinois Waterway

Major problems on the Illinois Waterway are ice in the upper lock approach and miter gate recesses and ice passage at the navigation dam. Severe ice accumulations and jams were reported at 10 locations, including a 20-mile stretch of Peoria Lake. Other ice-related problems include glazing of the miter gates, their recesses, and the lock walls, spray icing of the spillway gates and piers, and ice formation caused by leakage of tainter gate seals. Table 16 gives the relative severity of each of these problem areas.

#### Mississippi River

The surveyed portion of the Mississippi River covers 870 miles and contains 29 lock and dam facilities. Major problems include ice in the upper lock approaches and miter gate recesses, difficulties in passing ice over the spillway, and glazing of the lock walls and miter gates. Twenty-seven locations experience severe ice accumulations or jams. Additional ice-related problems include blockages due to tributary ice, spray from normal spillway gate operation, and ice formation due to leakage of tainter gate seals. Problem severities are listed on Table 17.

#### Kaskaskia River

The Kaskaskia River contains one lock and dam facility. Problems were reported concerning ice in the upper lock approach, ice jamming in the miter gate recesses, difficulties passing ice over the dam spillway, and glazing of the lock walls and miter gates. The severities of these problems are given in Table 18.

#### Missouri River

The Missouri River is navigable from St. Louis, Missouri, to Sioux City, Iowa. The project is a free-flowing river with navigation depths controlled by releases from the main stem reservoirs upstream of Sioux City. During the winter season (1 December to 31 March), releases from these multi-purpose

reservoirs are reduced to the levels necessary for power production and flood control operations, usually 1/3 to 1/2 of the summer flows. This reduces the river depth to below that which can support navigation. Ice conditions during the winter months often cause accumulations or jams, some minor flooding, and damage to rock structures and dock facilities. Due to the decreased depths and uncertainty of ice conditions, navigation interests have accepted an eight-month navigation season (1 April to 30 November) on the Missouri River.

#### CONCLUSION

Overall, the survey questionnaire approach to gathering ice problem information was successful. Information was acquired on problem types, locations, and severities as well as points of contact for further discussion. Methods of reducing the impact of ice problems by operational or structural means were cited. The superb response was primarily due to the Field Review Group being able to direct the questionnaire to individuals with first-hand knowledge.

Information from the survey has already been used by two work units of the RIM program. The Ice Control Structures work unit has identified possible sites where a control-type structure may prove beneficial. The Control of Ice at Locks work unit has found which ice problems at the lock and dam facilities are considered most severe, and a study plan has been formulated to look at these problems and to consider methods to relieve them, such as systems to keep the miter gate recesses clear. In the 1984-85 winter season, the Hydraulics and/or River Modification work unit will monitor the bends and islands that frequently experience ice jams, gathering data for further studies of the jamming process in these areas. It is expected that the survey results will be used by additional work units of the RIM program as well as other interested parties.

APPENDIX A: SAMPLE SURVEY QUESTIONNAIRE

1. Location: River \_\_\_\_\_  
Mile \_\_\_\_\_
2. Hydraulic structure: No \_\_\_\_\_ Yes \_\_\_\_\_  
Name \_\_\_\_\_
3. Problem area: Bend \_\_\_\_\_  
Island(s) \_\_\_\_\_  
Spillway Gates \_\_\_\_\_  
Lock Gates and/or Approaches \_\_\_\_\_
4. Description of problem: (use reverse side if necessary)  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
5. Documentation available: Reports\* \_\_\_\_\_  
Memos\* \_\_\_\_\_  
Individuals \_\_\_\_\_  
  
(\* copies appreciated if available)
6. Have there been any attempts to alleviate the problem?  
No \_\_\_\_\_ Yes \_\_\_\_\_  
If yes, Re-design \_\_\_\_\_  
Operational changes \_\_\_\_\_  
Reports \_\_\_\_\_
7. How does this problem rank with other ice problems in your jurisdiction in its impact on the operation of the structure/river system?  
High \_\_\_\_\_  
Medium \_\_\_\_\_  
Low \_\_\_\_\_

8. Identify any structures that have been specifically designed, modified, or retrofitted to alleviate this ice problem:

Site

Point of Contact

Address & Telephone Number

# APPENDIX B: LIST OF RESPONDENTS

<u>Lock and Dam Facility</u>	<u>River</u>
Lock No. 2	Allegheny
Lock No. 3	"
Lock No. 4	"
Lock No. 5	"
Lock No. 6	"
Lock No. 7	"
Lock No. 8	"
Lock No. 9	"
Lock No. 2	Monongahela
Lock No. 3	"
Lock No. 4	"
Maxwell L/D	"
Lock No. 7	"
Lock No. 8	"
Morgantown L/D	"
Hildebrande L/D	"
Opekiska L/D	"
Emsworth L/D	Ohio
Dashields L/D	"
Montgomery L/D	"
New Cumberland L/D	"
Pike Island L/D	"
Hannibal L/D	"
Willow Island L/D	"
Belleville L/D	"
Racine L/D	"
Gallipolis L/D	"
Greenup L/D	"
Meldahl L/D	"
Markland L/D	"
McAlpine L/D	"
Cannelton L/D	"
Newburgh L/D	"
Uniontown L/D	"
Smithland L/D	"
Lock 52	"
Lock 53	"
Winfield L/D	Kanawha
Marmet L/D	"
London L/D	"
O'Brien L/D	Illinois
Dresden Island L/D	"
Marseilles L/D	"
Starved Rock L/D	"
Peoria L/D	"
LaGrange L/D	"

Coon Rapids Dam	Mississippi
Upper St. Anthony Falls L/D	"
Lower St. Anthony Falls L/D	"
L/D 1	"
L/D 2	"
L/D 3	"
L/D 4	"
L/D 5	"
L/D 5A	"
L/D 6	"
L/D 7	"
L/D 8	"
L/D 9	"
L/D 10	"
L/D 11	"
L/D 12	"
L/D 14	"
L/D 15	"
L/D 16	"
L/D 17	"
L/D 18	"
L/D 19	"
L/D 20	"
L/D 21	"
L/D 22	"
L/D 24	"
L/D 25	"
L/D 26	"
L/D 27	"
Kaskaskia	Kaskaskia

#### Other Respondents

Pittsburgh District Office - Waterways Management Branch  
 Pittsburgh District Office - Engineering Division  
 Pittsburgh District Office - Allegheny/Ohio River Project Office  
 Pittsburgh District Office - Monongahela River Project Office  
 Huntington District Office - Operations Division  
 Louisville District Office - Operations Division  
 Louisville District Office - Engineering Division  
 Ohio River Division - Waterways Management Branch  
 St. Louis District Office - Operations Division  
 Kansas City District Office - Operations Division  
 Omaha District Office - Hydrologic Engineering Branch

**END**

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**9-85**

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